

What is claimed is:

- 1           1.       An apparatus comprising:  
2           an error filter coupled to an adaptive filter having N taps to filter a decision error  
3       provided by the adaptive filter using a leakage factor; and  
4           an updater coupled to the error filter and the adaptive filter to update N equalizer  
5       coefficients to the N taps using the filtered decision error, the updater receiving N  
6       equalizer data from the N taps.
  
- 1           2.       The apparatus of claim 1 wherein the error filter is a high pass filter.
  
- 1           3.       The apparatus of claim 1 wherein the error filter is a first-order high pass  
2       filter having a pole determined by the leakage factor.
  
- 1           4.       The apparatus of claim 1 wherein the error filter has a zero at zero  
2       frequency.
  
- 1           5.       The apparatus of claim 1 wherein the error filter comprises:  
2           a first computing element to compute an error difference of the decision error; and  
3           a second computing element coupled to the first computing element to generate  
4       the filtered decision error using the leakage factor.
  
- 1           6.       The apparatus of claim 5 wherein the first computing element comprises:  
2           a delay element to delay the decision error; and  
3           a subtractor to subtract the delayed decision error from the decision error to  
4       provide the error difference.
  
- 1           7.       The apparatus of claim 5 wherein the second computing element  
2       comprises:  
3           a delay element to delay the filtered decision error to provide a delayed output;  
4           a multiplier coupled to the delay element to multiply the leakage factor with the  
5       delayed output to generate a product; and

6 an adder coupled to the multiplier to add the error difference to the product to  
7 generate the filtered decision error.

1 8. The apparatus of claim 1 wherein the updater comprises:  
2 N coefficient updaters coupled to the error filter to generate the updated equalizer  
3 coefficients using the N equalizer data and the filtered decision error.

1 9. The apparatus of claim 8 wherein each of the N coefficient updaters  
2 comprises:  
3 a first multiplier to multiply a corresponding one of the equalizer data with the  
4 filtered decision error to provide a first product;  
5 a second multiplier coupled to the first multiplier to multiply the first product with  
6 an adaptive step size to provide a second product;  
7 a delay element to delay a corresponding one of the updated equalizer coefficients  
8 to provide a delayed coefficient; and  
9 a subtractor coupled to the second multiplier and the delay element to subtract the  
10 second product from the delayed coefficient, the subtractor providing the updated filtered  
11 coefficient.

1 10. The apparatus of claim 6 wherein the delay element delays the decision  
2 error by one sample.

1 11. The apparatus of claim 7 wherein the delay element delays the filtered  
2 decision error by one sample.

1 12. A method comprising:  
2 filtering a decision error provided by an adaptive filter using a leakage factor, the  
3 adaptive filter having N taps; and  
4 updating N equalizer coefficients to the N taps using the filtered decision error by  
5 an updater, the updater receiving N equalizer data from the N taps.

1           13.    The method of claim 12 wherein filtering the decision error comprises  
2   filtering the decision error by a high pass filter.

3           14.    The method of claim 12 wherein filtering the decision error comprises  
4   filtering the decision error by a first-order high pass filter having a pole determined by the  
5   leakage factor.

1           15.    The method of claim 12 wherein filtering the decision error comprises  
2   filtering the decision error by a first-order high pass filter having a zero at zero frequency.

1           16.    The method of claim 12 wherein filtering the decision error further  
2   comprises:  
3           computing an error difference of the decision error by a first computing element;  
4   and  
5           generating the filtered decision error using the leakage factor.

1           17.    The method of claim 16 wherein computing the error difference  
2   comprises:  
3           delaying the decision error; and  
4           subtracting the delayed decision error from the decision error to provide the error  
5   difference.

1           18.    The method of claim 16 wherein generating the filtered decision error  
2   further comprises:  
3           delaying the filtered decision error to provide a delayed output;  
4           multiplying the leakage factor with the delayed output to generate a product; and  
5           adding the error difference to the product to generate the filtered decision error.

1           19.    The method of claim 12 wherein updating the N equalizer coefficients to  
2   the N taps comprises:

3           generating the updated equalizer coefficients using the N equalizer data and the  
4           filtered decision error.

1           20.     The method of claim 19 wherein generating the updated equalizer  
2           coefficients comprises:

3                 multiplying a corresponding one of the equalizer data with the filtered decision  
4                 error to provide a first product;

5                 multiplying the first product with an adaptive step size to provide a second  
6                 product;

7                 delaying a corresponding one of the updated equalizer coefficients to provide a  
8                 delayed coefficient; and

9                 subtracting the second product from the delayed coefficient to provide the updated  
10                filtered coefficient.

1           21.     The method of claim 17 wherein delaying the decision error comprises  
2           delaying the decision error by one sample.

1           22.     The method of claim 18 wherein delaying the decision error comprises  
2           delaying the filtered decision error by one sample.

1           23.     A computer program product comprising:

2                 a machine useable medium having program code embedded therein, the program  
3                 code comprising:

4                         computer readable program code to filter a decision error provided by an  
5                         adaptive filter using a leakage factor, the adaptive filter having N taps; and

6                         computer readable program code to update N equalizer coefficients to the  
7                         N taps using the filtered decision error by an updater, the updater receiving N equalizer  
8                         data from the N taps.

1           24.     The computer program product of claim 23 wherein the computer readable  
2           program code to filter the decision error comprises computer readable program code to  
3           filter the decision error by a high pass filter.

1           25.     The computer program product of claim 23 wherein the computer readable  
2     program code to filter the decision error comprises computer readable program code to  
3     filter the decision error by a first-order high pass filter having a pole determined by the  
4     leakage factor.

1           26.     The computer program product of claim 23 wherein the computer readable  
2     program code to filter the decision error comprises computer readable program code to  
3     filter the decision error by a first-order high pass filter having a zero at zero frequency.

1           27.     The computer program product of claim 23 wherein the computer readable  
2     program code to filter the decision error comprises:  
3             computer readable program code to compute an error difference of the decision  
4     error; and  
5             computer readable program code to generate the filtered decision error using the  
6     leakage factor.

1           28.     The computer program product of claim 27 wherein the computer readable  
2     program code to compute the error difference comprises:  
3             computer readable program code to delay the decision error; and  
4             computer readable program code to subtract the delayed decision error from the  
5     decision error to provide the error difference.

1           29.     The computer program product of claim 27 wherein the computer readable  
2     program code to generate the filtered decision error further comprises:  
3             computer readable program code to delay the filtered decision error to provide a  
4     delayed output; and  
5             computer readable program code to multiply the leakage factor with the delayed  
6     output to generate a product; and  
7             computer readable program to add the error difference to the product to generate  
8     the filtered decision error.

1           30.     The computer program product of claim method of claim 23 wherein the  
2 computer readable program code to update the N equalizer coefficients to the N taps  
3 further comprises:  
4           computer readable program code to generate the updated equalizer using the N  
5 equalizer data and the filtered decision error.

1           31.     The computer program product of claim 30 wherein the computer readable  
2 program to generate the updated equalizer coefficients comprises:  
3           computer readable program code to multiply a corresponding one of the equalizer  
4 data with the filtered decision error to provide a first product;  
5           computer readable program code to multiply the first product with an adaptive  
6 step size to provide a second product;  
7           computer readable program code to delay a corresponding one of the updated  
8 equalizer coefficients to provide a delayed coefficient; and  
9           computer readable program code to subtract the second product from the delayed  
10 coefficient to provide the updated filtered coefficient.

1           32.     The computer program product of claim 28 wherein the computer readable  
2 program code to delay the decision error comprises computer readable program code to  
3 delay the decision error by one sample.

1           33.     The computer program product of claim 29 wherein the computer readable  
2 program code to delay the decision error comprises computer readable program code to  
3 delay the filtered decision error by one sample.

1           34.     A system comprising:  
2           an adaptive filter having N taps with N equalizer coefficients to generate an output  
3 sequence from an input signal, the adaptive filter generating an error decision; and  
4           a tap-leakage generator coupled to the adaptive filter comprising:  
5           an error filter coupled to an adaptive filter having N taps to filter the  
6 decision error using a leakage factor; and

7 an updater coupled to the error filter and the adaptive filter to update N  
8 equalizer coefficients to the N taps using the filtered decision error, the updater receiving  
9 N equalizer data from the N taps.

1 35. The system of claim 34 wherein the error filter is a high pass filter.

1 36. The system of claim 34 wherein the error filter is a first-order high pass  
2 filter having a pole determined by the leakage factor.

1 37. The system of claim 34 wherein the error filter has a zero at zero  
2 frequency.

1 38. The system of claim 34 wherein the error filter comprises:  
2 a first computing element to compute an error difference of the decision error; and  
3 a second computing element coupled to the first computing element to generate  
4 the filtered decision error using the leakage factor.

1 39. The system of claim 38 wherein the first computing element comprises:  
2 a delay element to delay the decision error; and  
3 a subtractor to subtract the delayed decision error from the decision error to  
4 provide the error difference.

1 40. The system of claim 38 wherein the second computing element comprises:  
2 a delay element to delay the filtered decision error to provide a delayed output;  
3 a multiplier coupled to the delay element to multiply the leakage factor with the  
4 delayed output to generate a product; and  
5 an adder coupled to the multiplier to add the error difference to the product to  
6 generate the filtered decision error.

1 41. The system of claim 34 wherein the updater comprises:  
2 N coefficient updaters coupled to the error filter to generate the updated equalizer  
3 coefficients using the N equalizer data and the filtered decision error.

1           42.     The system of claim 41 wherein each of the N coefficient updaters  
2 comprises:  
3           a first multiplier to multiply a corresponding one of the equalizer data with the  
4 filtered decision error to provide a first product;  
5           a second multiplier coupled to the first multiplier to multiply the first product with  
6 an adaptive step size to provide a second product;  
7           a delay element to delay a corresponding one of the updated equalizer coefficients  
8 to provide a delayed coefficient; and  
9           a subtractor coupled to the second multiplier and the delay element to subtract the  
10 second product from the delayed coefficient, the subtractor providing the updated filtered  
11 coefficient.

1           43.     The system of claim 39 wherein the delay element delays the decision  
2 error by one sample.

1           44.     The system of claim 40 wherein the delay element delays the filtered  
2 decision error by one sample.